Space Weather Technical Forecast

Issued on Thursday, 16 December 2021 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Numerous sunspots on the earth-facing disc. Chance of Moderate class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity was Low, with many C-class flares in the past 24-hours, mainly from AR2907. The largest of these was a C8.1 flare at 15/1044UTC.

There are currently five numbered sunspot regions on the visible disc and one unnumbered region. Most notably AR2907 (Dai/Beta-gamma) continues to grow in size, though appears to have reduced in complexity in the past 12 hours with no further evidence of a delta spot on the lead portion of the group. The small trailer spot in AR2906 (Csi/Beta) has decayed, with the lead spot now more symmetric in appearance, though some weak spots have developed between the lead and trailer portion of the group. AR2905 (Axx/Alpha) continues to fade, still barely visible. AR2908 remains a Dao/Beta type, and continues to show growth, especially in its lead spot, with another strong spot developing within the group. AR2909 (Dao/Beta) closest to the southeast limb appears to have a similar spot configuration and has also grown in recent hours, although slower in its growth than its neighbouring group AR2908. There remains another small unnumbered spot group approaching centre disc in the northeast quadrant, Bxo/Beta, which continues with weak and small spot proliferation. An area of plage looks to be emerging over the northeast limb at present. This will be monitored for the possible presence of further sunspot regions.

No Earth-directed CMEs have been observed in available imagery.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured at L1, was at background levels initially, however, after 15/0300UTC speeds increased steadily to reach current values around 550km/s. This was due to the connection to the fast wind from coronal hole 32. A slow decline to 500-520 km/s followed through the rest of the period. Density was mainly above average, peaking at around 31ppcc just prior to the connection with coronal hole 32. The Interplanetary Magnetic Field strength (IMF) Bt was weak but again rose to a peak near 16nT, as the high speed stream arrived. It has now returned to weak levels, around 6nT. A similar trend was observed with the Bz component, peak +14nT to -15nT around the high speed stream arrival time. The Phi angle was largely negative (towards the sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) was at mainly Background levels with the associated 24-hour integrated fluence well below the Active threshold. Fluence of 1.92e6 was observed at 16/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar Activity is expected to be Low or Very low, but with a chance of M-class flares and a very slight chance of X-class flares given the current complexity of and increasing numbers of sunspot regions on the visible disc. Further sunspot regions may rotate onto the

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

visible disc in the coming days to supplement the current risk of significant flares.

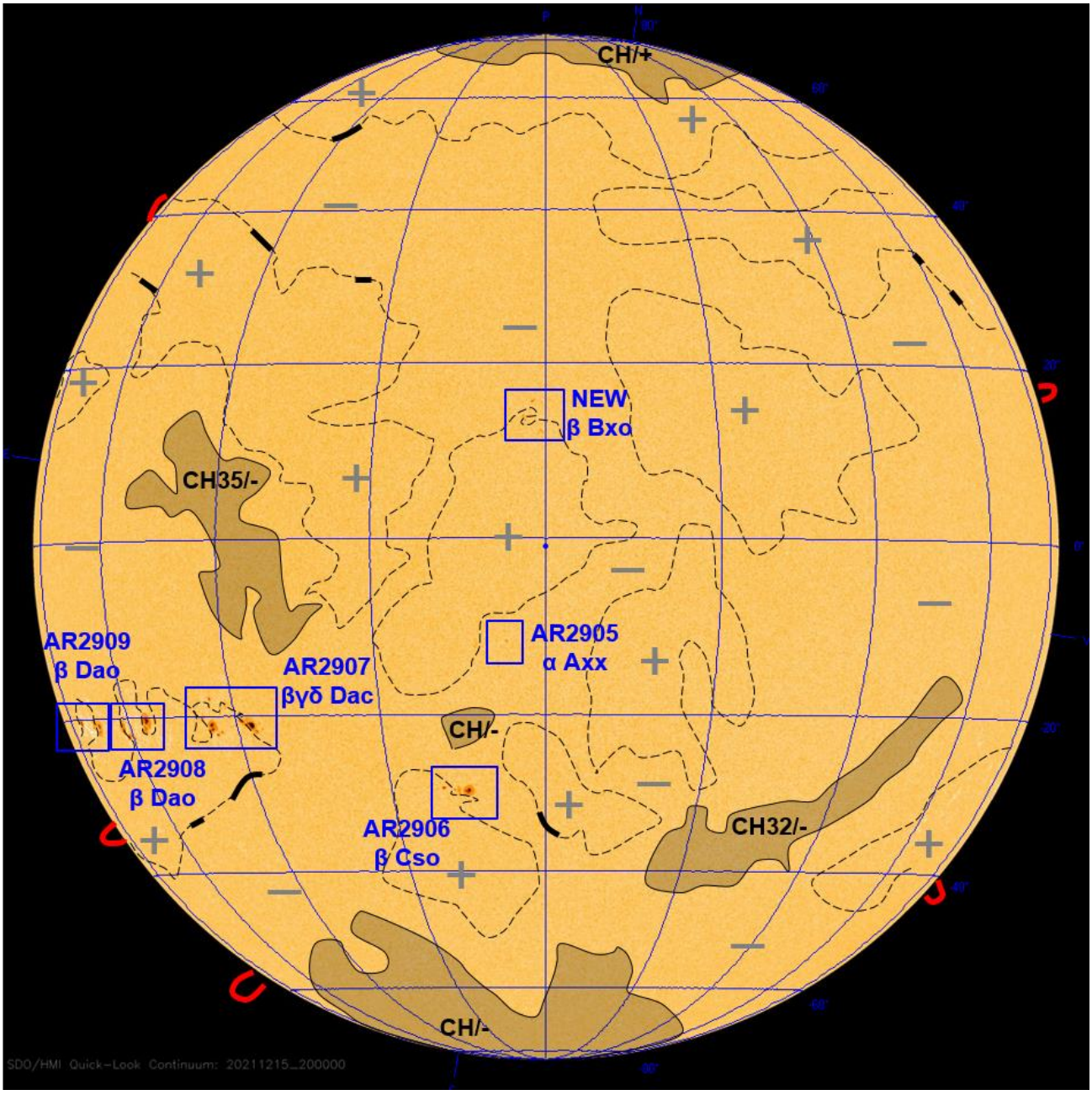
Solar Wind / Geomagnetic Activity: Solar winds are currently at elevated levels following connection with the high-speed stream from coronal hole 32 early on the 15th. Solar wind speeds should gradually ease over the coming days to become background by day 2 or 3 (17th or 18th). No further coronal hole enhancements are anticipated during the period and no earth-directed CMEs are forecast. Geomagnetic activity is expected to be Quiet to Unsettled initially on day 1 (16th). From the middle of day 1 onwards Quiet geomagnetic conditions should be predominant.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels, although with a slight increasing risk with time as the numerous sunspots on the visible disc transit to a more favourable location relative to earth's position. The high energy (greater than 2 MeV) electron flux, as observed by GOES-16, is expected to be at Background to Moderate levels initially. Persistently High flux is possible by day 2 and may continue into days 3 and 4 (18th and 19th), although confidence is low in this aspect of the forecast. The associated 24 hour fluence is expected to persist well below the Active level on day 1, with an increasing chance of rising above by day 3 and 4.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

Figure 1. Solar Analysis Valid 15/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

Met Office Space Weather Technical Forecast

Geomagnetic Storms:

No Earth-directed CMEs have been observed in available coronograph imagery.

Connection with coronal hole 32 was established in the early hours UTC of the 15th with elevated winds of around 510 km/s currently. Solar wind speeds should gradually ease over the coming days to become background by day 2 or 3 (17th or 18th). No further coronal hole enhancements are anticipated during the period.

Geomagnetic activity is expected to be Quiet to Unsettled initially on day 1 (16th). From the middle of day 1 onwards Quiet geomagnetic conditions should be predominant.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections - Nil

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

Radio Blackouts - X-Ray Flares:

There are currently five numbered sunspot regions on the visible disc and one unnumbered region.

Most notably AR2907 (Dai/Beta-gamma) continues to grow in size, though appears to have reduced in complexity in the past 12 hours with no further evidence of a delta spot on the lead portion of the group.

The small trailer spot in AR2906 (Csi/Beta) has decayed, with the lead spot now more symmetric in appearance, though some weak spots have developed between the lead and trailer portion of the group.

AR2905 (Axx/Alpha) continues to fade, still barely visible.

AR2908 remains a Dao/Beta type, and continues to show growth, especially in its lead spot, with another strong spot developing within the group.

AR2909 (Dao/Beta) closest to the southeast limb appears to have a similar spot configuration and has also grown in recent hours, although slower in its growth than its neighbouring group AR2908.

There remains another small unnumbered spot group approaching centre disc in the northeast quadrant, Bxo/Beta, which continues with weak and small spot proliferation.

An area of plage looks to be emerging over the northeast limb at present. This will be monitored for the possible presence of further sunspot regions.

The cluster of sunspot regions in the southeast quadrant of the solar disc will be closely monitored over the coming days. For now Low or Very Low activity is expected with a 35% chance of M-class and 5% risk of X-class flares given the current configuration of sunspots on the visible disc. Further active regions are likely to rotate into view over the next week as suggested from the side-view of the Sun provided by STEREO A.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	35	35	35	35
Very Active	R3 to R5 X Class	No	5	5	5	5

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

Figure 2: HMI Intensitygram (left image) and HMI Colorized Magnetogram (right image) at 16/0000 UTC. Sunspots AR2909, AR2908, AR2907 and AR2906 (right to left) in the southeastern quadrant.

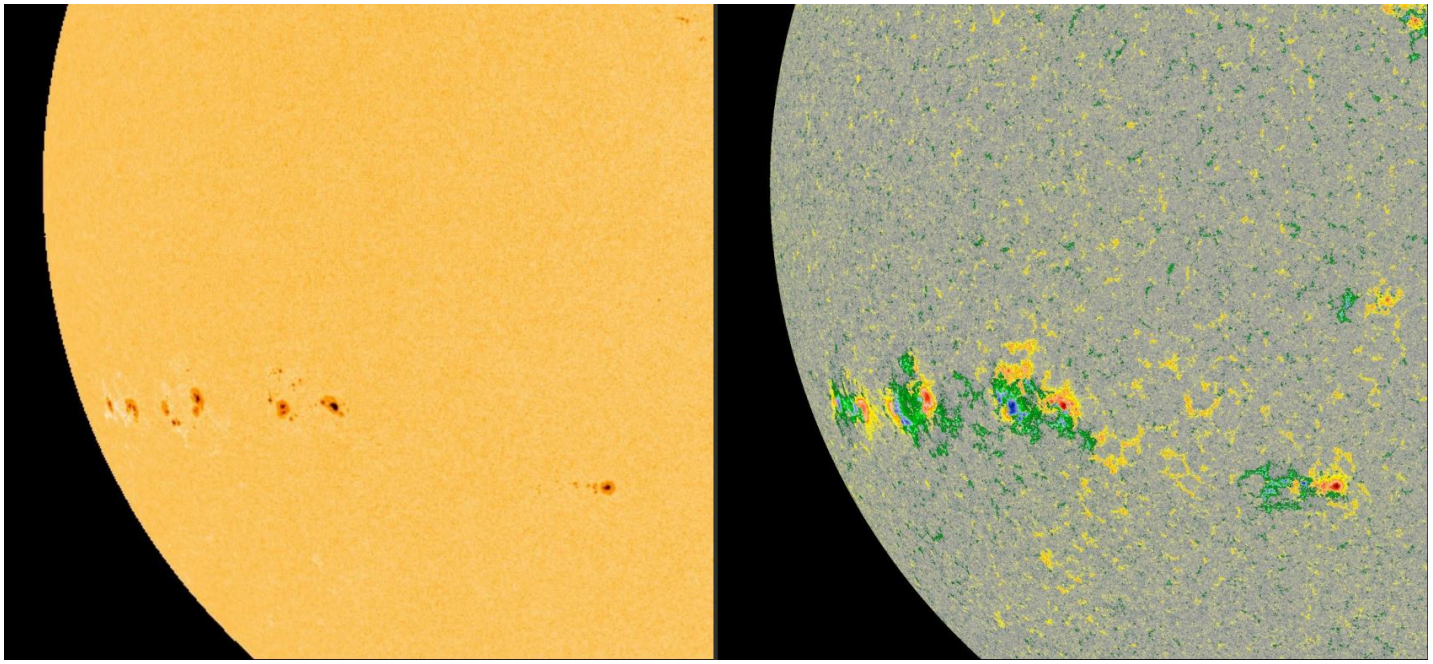
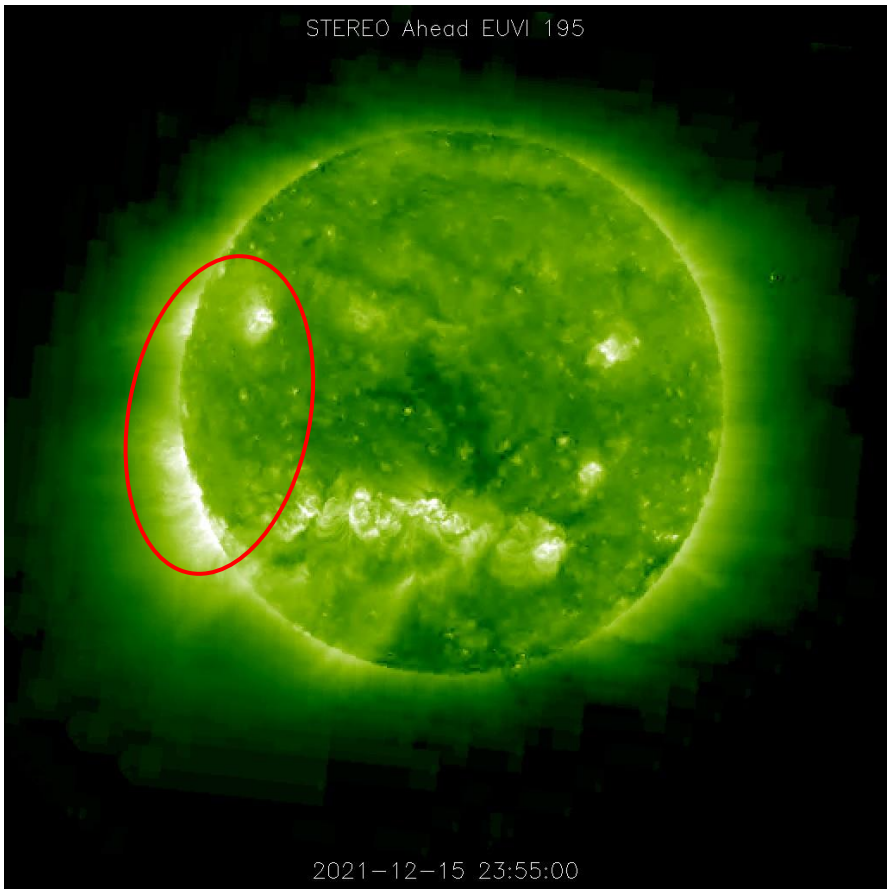


Figure 3: STEREO A EUVI 195 imagery at 15/2355 UTC. Numerous bright flux regions near the eastern limb (circled), likely containing sunspots, could rotate onto the earth-facing disc in the coming days.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently expected to remain at background levels. Increasing sunspot activity may warrant a slight increase of chance of S1 radiation storming over the next few days, though at present the most significant active regions are in the eastern hemisphere of the solar disc. As a result any large flares are less likely to cause Solar Radiation Storms at Earth. The sunspot regions will pose more of a risk when they move into the western quadrant if they are still active.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	3	3
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as observed by GOES-16, is expected to be at Background to Moderate levels initially. Flux enhancement of radiation belt electrons, following the initial suppression from the corotating interaction region (CIR) of coronal hole 32, should take place on days 1 and 2 (16th and 17th). Persistently High flux is possible by day 2 and may continue into days 3 and 4 (18th and 19th), although confidence is low in this aspect of the forecast.

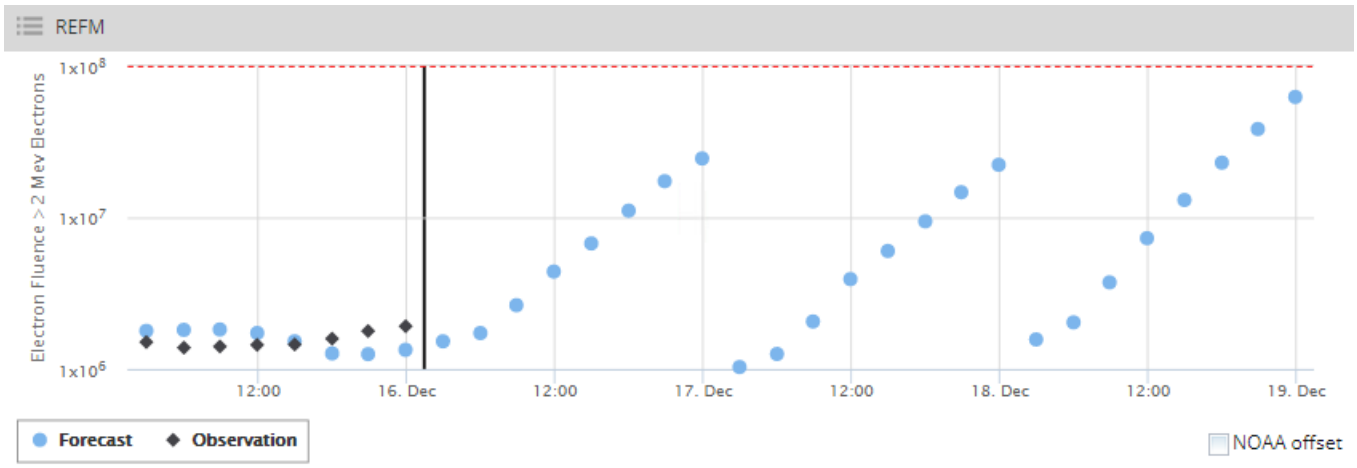
The associated 24 hour fluence is expected to persist well below the Active level on day 1, with an increasing chance of rising above by day 3 and 4. This is supported by REFM which maintains fluence below the Active threshold, but gets close to the Active threshold by the start of day 3.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	20	40	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.

Figure 4: Latest MOSWOC REFM output.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2021. All Rights Reserved.